TOPIC 16 – KINETICS
16.3 – ACTIVATION ENERGY

IB Chemistry

T16D08

16.3 Activation energy - 2 hours

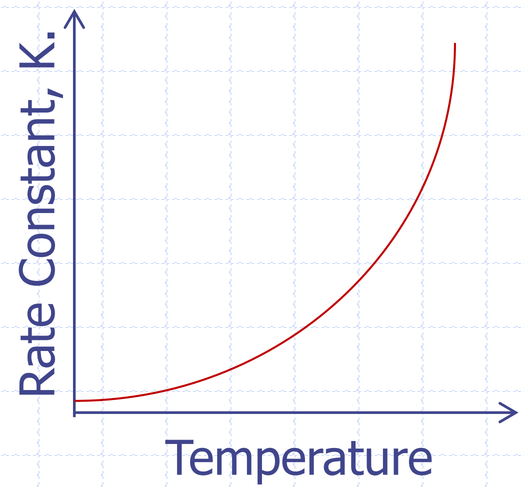
- 16.3.1 Describe qualitatively the relationship between the rate constant (k) and temperature (T). (2)
- 16.3.2 Determine activation energy (Ea) values from the Arrhenius equation by a graphical method. (3)

16.3.1 – Effect of Temperature

- 16.3.1 Describe qualitatively the relationship between the rate constant (k) and temperature (T). (2)
- When T increases, the rate increases rapidly
- It has been found that for many reactions the initial rate and rate constant, k, vary with temperature exponentially
- This relationship between absolute temperature and the rate constant is modeled by the **Arrhenius equation**:

16.3 – Arrhenius Equation

- The Arrhenius equation is relevant to gases, solutions, and reactions on the surface of a solid catalyst
- E_a and A are both constants
- R is a fundamental physics constant
- T and k are variables
- 3 constants = insignificant Δ with T
- For large effect of increase in T:
  - Exponential Factor



16.3 – Arrhenius Variables

- A, represents the **Arrhenius constant**
  - Same units as rate constant, k
  - Measure of the proportion of molecules that collide with enough KE to react and which also have the correct collision geometry
- E_a, represents the **activation energy**
- T, represents the **absolute temperature** (K)
- R, represents the **gas constant** (8.31 $JK^{-1}mol^{-1}$)

16.3 – Arrhenius Equation

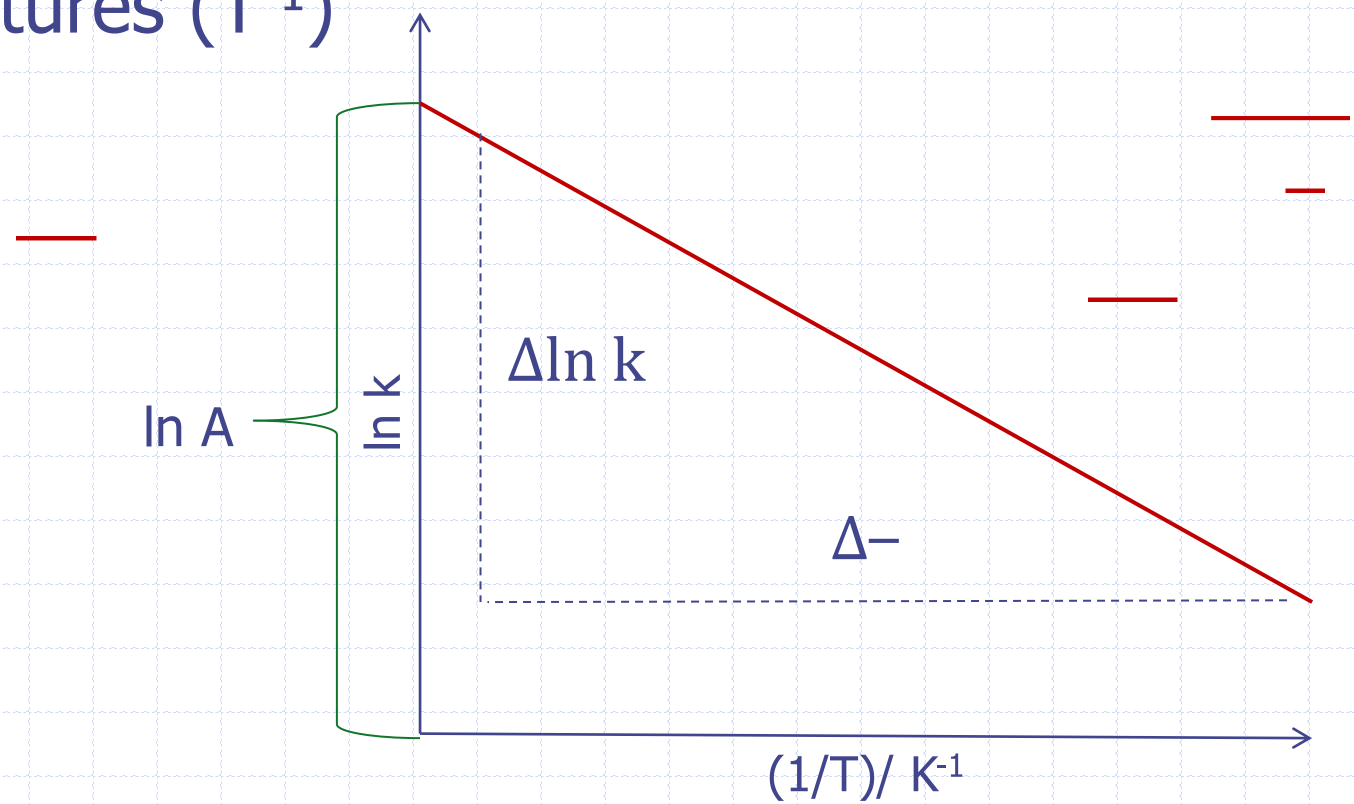
- The Arrhenius equation ( ) is used to calculate the E_a and A of a reaction
  - First experimentally measure the rate constants at several temperatures
  - The following equation (rearrangement of the Arrhenius equation) is used to transform data so that an Arrhenius plot can be produced:

16.3.2 – Calculating E_a's

- 16.3.2 Determine activation energy (E_a) values from the Arrhenius equation by a graphical method. (3)
- The slope (or gradient) of an Arrhenius plot is equal to the value of $-E_a/R$, and the y-intercept is ln A
- Once E_a is determined, the Arrhenius constant, A, can be calculated by substitution into the Arrhenius equation

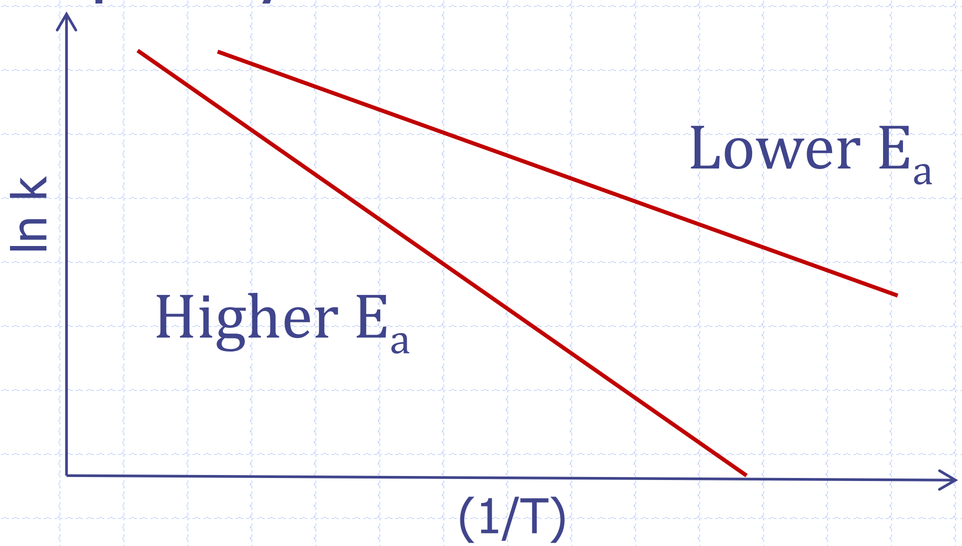
16.3 – Arrhenius Plot

- An Arrhenius plot is a graph of the natural logarithm of the rate constant, k, against the reciprocal of the corresponding absolute temperatures (T^{-1})



16.3 – Relative Plot Gradients

- If Arrhenius plots are drawn on the same axes for two reactions with different E_a's you can see that the reaction with the higher activation energy has a steeper gradient (as the E_a is part of the gradient)
- This indicates that:
  - The rate constant, k, and initial rate, will change with T much more quickly than the reaction with the lower E_a.



16.3 - Catalysts

- Catalysts are substances that increase the rate constant of a particular chemical reaction but remain chemically unchanged
- Three types of catalysts:
  - Homogeneous catalysts
    - Same state as reactants
  - Heterogeneous catalysts
    - Different state than reactants
  - Enzymes
    - Biological catalysts in living cells. Large globular protein molecules with a large number of amino acids
    - Often contain a metal ion on the **active site**

16.3 – Types of Catalysts

- **Promoters** increase the rates of reaction
- **Inhibitors** slow down the reaction rates by reacting and removing intermediates
- **Catalysts Poisons** greatly reduce the rates of catalyzed reactions by binding to the catalytic site of a heterogeneous catalyst. (arsenic, CO, HCN)
- The [concentration] and surface area of a catalyst often affects the rate of reaction

16.3 – Homogeneous Catalysts

16.3 – Heterogeneous Catalysts

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